

**ALBERTA TRANSPORTATION  
GEOHAZARD ASSESSMENT PROGRAM  
NORTH CENTRAL REGION – ATHABASCA AND  
FORT MCMURRAY DRISTRICTS  
2021 SITE INSPECTION**



Site Number	Location	Name	Hwy	km
NC104	Approximately 7.7 km north of Hwy 29 (North of Elk Point)	<b>KEHIWIN LAKE</b>	41:23	7.7
Legal Description		UTM Co-ordinates (NAD 83)		
NE-25-58-7-W4M		12 N 5988325	E	506652

	Date	PF	CF	Total
<b>Previous Inspection:</b>	June 12, 2019	8	4	32
<b>Current Inspection:</b>	June 25, 2021	11	4	44
<b>Road AADT:</b>	1,230	<b>Year:</b>	2020	
<b>Inspected By:</b>	José Pineda, Tarek Abdelaziz (Thurber) Kristen Tappenden, Bernard Ching (Alberta Transportation)			
<b>Report Attachments:</b>	<input checked="" type="checkbox"/> Photographs <input checked="" type="checkbox"/> Plans <input type="checkbox"/> Maintenance Items			

<b>Primary Former Site Issue:</b>	Landslide (NC104, previously known as NC24C) developed abruptly to the south of the km 7.8 pile wall (NC103 site previously known as NC24A) after occurrence of heavy rainfall events in 2011, causing pavement distress in the highway surface.
<b>Dimensions:</b>	Cracked section of highway to the south of the southern limit of the NC103 site: About 180 m long (parallel to the highway alignment) and 80 m wide (parallel to the slope direction).  Area susceptible to future local landslides to the south of the cracked section of the highway: About 160 m long.
<b>Date of any remediation:</b>	Remedial measures were implemented between the fall of 2016 and the fall of 2017 and consisted of the following: (a) the construction of a 230 m long cast-in-place tied-back pile wall to the south of NC24A to retain the cracked section of the highway (NC24C tied-back wall), (b) the construction of a 125 m cast-in-place cantilever pile wall (NC24 pile wall extension) to the south of the NC24C tied-back wall as a precautionary measure against future landslides. The NC24C pile wall extension (NC24C interim pile wall) was designed to accommodate the installation of additional piles, anchors and waler (if needed) in the future subject to instrumentation monitoring results, (c) installation of twin culverts and lining of C2 culvert by others, (d) grouting of culvert C1, ditch regarding and lining with TRM. Slope inclinometers load cells were installed in the NC24C tied-back pile wall to monitor the wall movement and anchor loads. Slope inclinometers, a Shape Accelerometer Array (SAA) and strain gauges were installed in selected piles of the NC24C pile wall extension to assess wall movements and the bending moment in one of the piles.
<b>Maintenance:</b>	After the first site visit was completed on May 12, 2011, the most pronounced distressed area of the highway surface was patched in the fall of 2011; patched again in fall 2012; cracks opened again and sealed in the early spring of 2013; cracks were sealed in June 2014. ACP patch was completed after construction in the fall of 2017.

Observations:	Description	Worse?
<input type="checkbox"/> Pavement Distress	N/A	<input type="checkbox"/>
<input type="checkbox"/> Slope Movement	N/A	<input type="checkbox"/>
<input type="checkbox"/> Erosion		<input type="checkbox"/>
<input type="checkbox"/> Seepage		<input type="checkbox"/>
<input type="checkbox"/> Bridge/Culvert Distress		<input type="checkbox"/>
<input checked="" type="checkbox"/> Other	Sharp drop off on the west side of highway due to previous ACP patches; cattails in the south ditch	<input type="checkbox"/>
<b>Instrumentation: (1SAA, 16SIs, 7PNs, 5SPs, 16VCs, 18SGs)</b>		
<p>The following provides the slope inclinometers' rate of movements in the Spring of 2021:</p> <ul style="list-style-type: none"> <li>• SI15-15 (located in the east ditch within the southern limit of the landslide) = 0.7 mm/yr.</li> <li>• SI15-16 and SI15-21 (located near the west edge of the highway downslope of the pile walls) ranged between 0.1 and 1.0 mm/yr.</li> <li>• SI12-11, SI15-7, SI15-20 (located at the bottom of the highway west side slope) ranged between 0.9 and 2.6 mm/yr.</li> </ul> <p>Total pile head movement (between fall 2020 and spring 2021):</p> <ul style="list-style-type: none"> <li>• N24C tied-back pile wall: SI16-1= -6.2 mm, SI16-2 = -4.7 mm, SI16-3 = -3.6 mm, SI16-4 = -4.3 mm, SI16-5 = -1.3 mm.</li> <li>• N24C Interim pile wall: SI17-1= 3.2 mm, SI17-2 = 8.8 mm, SI17-3 = 15.5 mm, SI17-4 = 9.4 mm, SAA17-1 = 1.9 mm.</li> </ul> <p>Vibrating wire load cell readings ranged from 179 kN to 256 kN; The readings of the strain gauge, installed in Pile 146 of the NC24C Interim pile wall, are still below warning threshold values.</p> <p>Groundwater levels fluctuated in the piezometers and ranged from an increase of 0.4 m in SP12-9 to a decrease of 0.5 m in PN15-16.</p>		
<b>Assessment (Refer to attached Figure):</b>		
<p>The site observations and instrumentation readings indicate that implemented remedial measure has been effective in stabilizing the landslide mass. Reflective highway surface cracks may however appear over time until the pile wall mobilizes the full magnitude of the stabilizing force.</p> <p>At present, the four slope inclinometers installed in the interim pile wall show that the pile head deflections (3mm, 9 mm, 10 mm, 15.5 mm) are approaching the suggested control deflection value (i.e., 16 mm). The pile head deflection in one of the piles has already exceeded the warning threshold value (i.e., 12 mm). There is a concern regarding the integrity of the cantilever pile wall. If the piles move excessively or fail in the future, an abrupt movement of the landslide and hence the highway will take place.</p> <p>The presence of cattails in the ditch may indicate poor surface drainage in the ditch, but this will need to be confirmed through further monitoring of the site. Poor drainage, and possibly water ponding, in the ditch can result in elevated groundwater levels and an accelerated landslide movement at the interim pile wall location.</p> <p>The existing sharp drop off near the edge of pavement still constitutes a safety hazard to runaway vehicles.</p> <p>The probability of failure increased from 8 to 11 to account for potential excessive movement of the interim pile wall.</p>		

**Recommendations:**

This site should be visited again in the spring of 2023, as per the GRMP's schedule, assuming that the interim pile wall instrumentation are read semi-annually at this site. These instruments are currently read annually.

The local MCI should watch closely for the development of any cracks in the highway section above the pile wall extension and notify us immediately. Cracks should generally be sealed to reduce ground water infiltration into the landslide mass.

The local MCI should also check whether the south ditch is draining towards the C2 pipe and the twin culverts. If water is ponding within the ditch, consideration should be given to re-grading the ditch to promote positive drainage.

Consideration should be given for placing the least amount of fill off the highway surface to smoothen the existing sharp drop off and eliminate the existing hazard. Otherwise, sharp shoulders warning signs should be erected to warn the motorists of the existing hazard.

The installation of the full retaining wall system (i.e., anchors and waler) should be considered for the interim pile wall before the structural integrity of the piles is compromised.

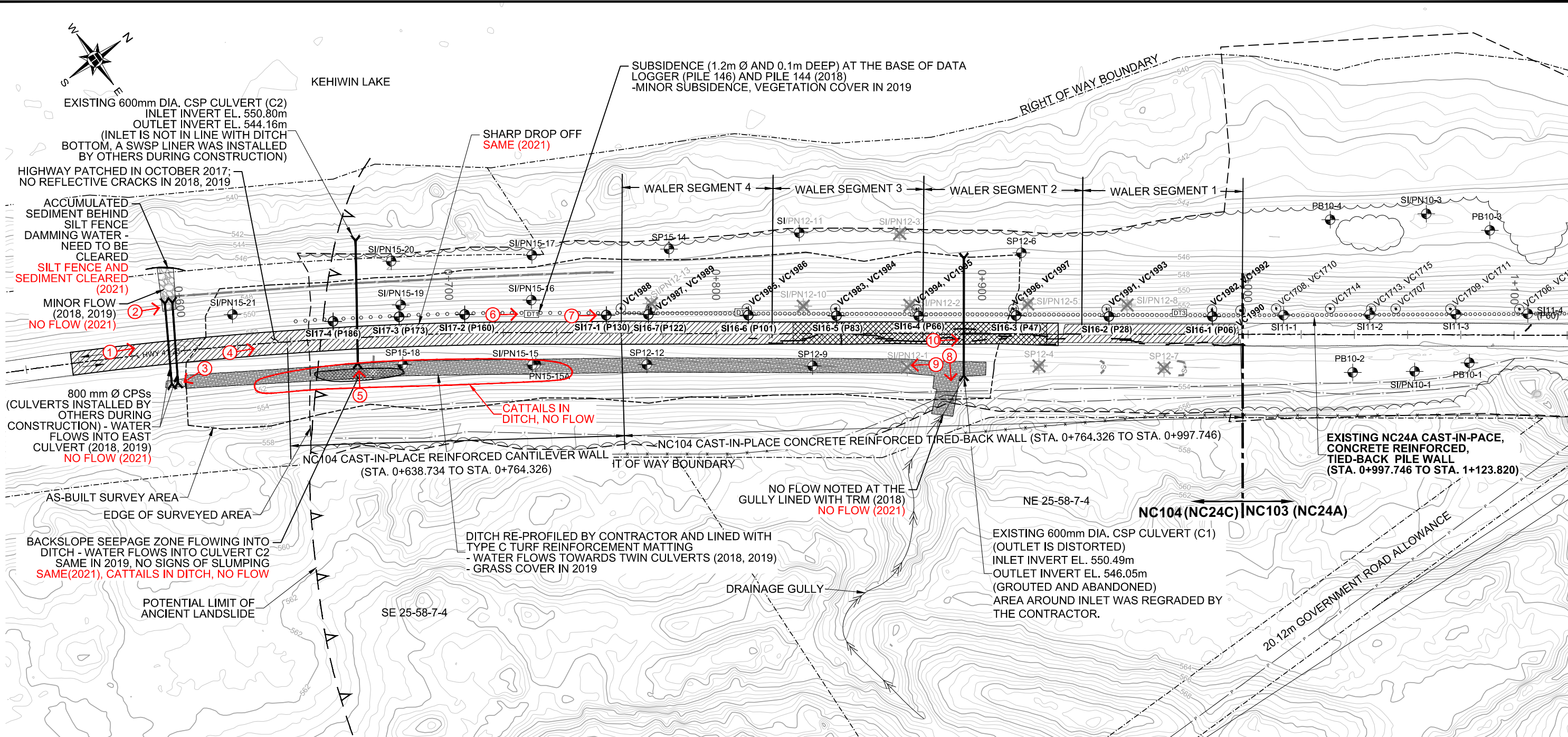
**Closure**

It is a condition of this letter report that Thurber's performance of its professional services will be subject to the attached Statement of Limitations and Conditions.

Tarek Abdelaziz, Ph.D., P.Eng.  
Principal | Senior Geotechnical Engineer

José Pineda, M.Eng., P.Eng.  
Senior Geotechnical Engineer

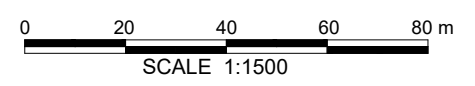
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LEGEND	
	PILE WALL
	FENCE LINE
	BUSH LINE
	ACTIVE SLIDE CRACKS ON HIGHWAY
	TEST HOLE LOCATION
	DAMAGED INSTRUMENT
	SI SLOPE INCLINOMETER
	PN PNEUMATIC PIEZOMETER
	SP STANDPIPE PIEZOMETER
	PB POORBOY
	VC VIBRATING WIRE LOAD CELL
	SAA SHAPE ACCELEROMETER ARRAY
	DATALOGGER
	—550— GROUND SURFACE CONTOUR
	—P— OVERHEAD POWER LINE (APPROXIMATE)
	—T— TELUS LINE (APPROXIMATE)
	—S— SILTY FENCE
	⊙ VIBRATING WIRE LOAD CELL LOCATION
	▨ PAVEMENT DISTRESS AREA
	▨ ACP PATCH (OLD)
	▨ RIP RAP
	① PHOTOGRAPH NUMBER, AND APPROXIMATE DIRECTION AND LOCATION

Load Cell Serial #	Anchor
VC1990	G0001S
VC1982	G007U
VC1992	G007L
VC1993	G029U
VC1991	G029L
VC1997	G049U
VC1996	G049L
VC1995	G070U
VC1994	G070L
VC1984	G087U
VC1983	G087L
VC1985	G106U
VC1986	G106L
VC1987	G126U
VC1989	G126L
VC1988	G132S

- NOTES:**
1. FEATURE LOCATIONS ARE APPROXIMATE.
  2. PREVIOUS OBSERVATIONS ARE SHOWN IN BLACK.
  3. **JUNE 25, 2021 OBSERVATIONS ARE SHOWN IN RED.**
  4. CONTOUR INTERVAL IS 0.5m.
  5. CONTOURS INSIDE SURVEYED AREA WERE SURVEYED BY WSP. ELEVATION CONTOURS OUTSIDE SURVEYED AREA WERE DERIVED FROM LIDAR DATA.
  6. INSTRUMENTS AND DATALOGGERS INSTALLED DURING CONSTRUCTION ARE SHOWN IN BOLD.
  7. SHAPE ACCELEROMETER ARRAY AND STRAIN GAUGES ARE CONNECTED TO DT1 (CAMPBELL SCIENTIFIC CR6 DATALOGGER, SERIAL No. 5839); LOAD CELLS VC1983 - VC1989, VC1994, VC1995 ARE CONNECTED TO DT2 (RST DT2040 DATALOGGER, SERIAL No. 2202); AND LOAD CELLS VC1982, VC1990 - VC1993, VC1996, VC1997 ARE CONNECTED TO DT3 (RST DT2040 DATALOGGER, SERIAL No. 2203).
  8. SHAPE ACCELEROMETER ARRAY AND STRAIN GAUGES ARE INSTALLED IN PILE P146.



**NORTH CENTRAL REGION  
(ATHABASCA AND FORT McMURRAY DISTRICTS)  
2021 GEOHAZARD ASSESSMENT  
NC104: HWY 41:23 LANDSLIDE (km 7.7)  
SITE PLAN SHOWING SITE FEATURES AND  
INSTRUMENT LOCATIONS**

**DWG NO. 32122-NC104-1**

DRAWN BY	ML
DESIGNED BY	JGP
APPROVED BY	TSA
SCALE	1:1500
DATE	AUGUST 2021
FILE No.	32122

**THURBER ENGINEERING LTD.**



Photo No. 1 - Looking north at highway surface; no reflective cracks or dips noted in 2021



Photo No.2 - Looking northeast at the twin culverts outlets; Sediment and silt fence cleared; no flow in 2021



Photo No.3 - Looking at the twin culverts inlets; no flow in 2021



Photo No.4 - Looking north at the TRM lined ditch; no water flowing; note cattails in the ditch area



Photo No.5 - Looking at culvert C2 inlet; no flow in 2021



Photo No.6 - Looking at data logger DT1 installed at pile 146 location; vegetation grew at previously noted subsidence at the base of the data logger



Photo No.7 – Looking north at sharp drop off shoulder on the west side slope



Photo No. 8 – Looking at gully lined with TRM; note lush vegetation but no flow in 2021





Photo No. 9 – Looking south at TRM lined ditch; note lush vegetation but no flow in 2021



Photo No. 10 – Looking north at the highway surface from the northern limit of the site